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AUTHOR Berger, Robert
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ABSTRACT

The paper reviews the literature on use of computers with retarded students in three chapters dealing respectively with the historical context, current issues, and future directions. The chapter on the historical context reviews research on the efficacy of teaching machines with this population. Research on the effectiveness of computer-assisted instruction and computer-assisted learning as an adjunct to teacher instruction is reviewed in the second chapter. The third chapter looks at new applications of computer technology in the areas of simulation, artificial intelligence, and robotics. Each chapter has its own reference list for a total of 59 references in all. (DB)

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Teaching Mild to Moderately Retarded Students with Computers

Robert Berger
Research project
Long Island University
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Chapter 1: Historical Review

Computer assisted instruction is rooted in work done on teaching machines and programmed instruction in the 1950's and 1960's. B.F. Skinner, who was a leader in the field, has commented, "When I go back and look at the machines I invented, I can see that they were just efforts to do mechanically what can now be done much more smoothly with computers. For the whole notion of presenting material and evaluating an answer, computers can perform beautifully now" (Green, 1984, p. 26).

A major researcher in the area of teaching machines and programmed instruction, Stolurow (1961) defined a teaching machine as a mechanism that presents information to a student and controls his behavior in a predetermined interacting relationship. Stolurow (1960) identified eight important characteristics of teaching machines:

1) Display. The machine presents the learner with a statement followed by a question.
2) Response. The machine requires an overt and measurable response.
3) Comparator. The machine compares or allows the learner to compare his response with the correct response.
4) Feed-back. The machine may supply knowledge of results to the learner in any number of ways.

5) Programming. The machine supplies information sequentially according to a system of rules.

6) Pacing. The machine may present information to the learner at a variable rate.

7) Collator. The machine measures and records the learning process.

8) Selective. The machine presents items to the learner on the basis of his previous responses.

Teaching machines need not have possessed all of these functions.

The particular utility of teaching machines for the educable mentally retarded was outlined by Blackman (1964):

1) Retarded students are slow learners. The teacher may not have the time or temperament to deal with them. A teaching machine has unlimited patience and can be programmed to present information at a slow rate.

2) Before placement in special education, educable mentally retarded students did not receive the usual rewards for good achievement in school. A teaching machine can be designed to deliver tangible reinforcement.

3) The mentally retarded is a highly diverse group. Teaching machines' pacing function allows for individual differences.

4) Teaching machines facilitate the high level of mastery required by the retarded.

5) Teaching machines provide an excellent opportunity to evaluate school materials.

Studies of the effectiveness of teaching machine instruction for the educable mentally retarded were conducted in the 1960's. Several of the more notable ones are described here.

A study of the use of teaching machines to present arithmetic programs to the mentally retarded (Price, 1961) was performed at a residential school for the mentally retarded in Alabama. The subject matter was the 12 factor table in addition and subtraction. The teaching machine employed required a student to answer a problem, turn a roller, and compare his response to the correct one. Thirty-six students were divided into three teaching groups:

1) answer construct, requiring that the answer be written,

2) multiple choice, requiring a correct answer to be chosen and marked,

3) conventional teaching.

Groups were equated for chronological age, mental age, IQ, and arithmetic level. Each received one half hour of arithmetic instruction daily. It became necessary to assign monitors to the machine taught students, because

they learned to cheat by lifting the clear plastic covering their answers. Two tests, consisting of addition and subtraction problems, were administered to gauge progress.

Both the machine groups and the conventionally taught showed significant improvement in their pre-test and post-test scores for addition. Only the multiple choice group showed significant improvement for subtraction. The conventionally taught group spent 130 half hour periods studying arithmetic, while the two machine groups averaged 86 half hour periods to complete the programs. Price (1961) concluded that teaching machines may be a "useful supplementary approach to teaching students who are mentally retarded" (p. 7).

A Florida study of the use of teaching machines to present reading programs (Malpass, Gilmore, Hardy, and Williams, 1963) was performed in public school special education classes and at a state institution for the retarded. Two teaching machines were employed in the project--multiple choice and keyboard devices. The multiple choice machine required students to select the correct response from three keys. A correct response was signalled by a light and a buzzer. An incorrect choice was not signalled. The keyboard machine, combined with a filmstrip projector, required students to select the correct response from thirty-two keys. Only when a correct response was

given did the machine advance to the next frame.

Both the public schools' sample (66 subjects) and the institutional sample (33 subjects) were matched on sex, chronological age, mental age, programmed words known, and a standardized reading achievement test. Each was divided into three teaching groups:

1) multiple choice machine

2) keyboard machine

3) conventional teaching.

Seventy-two words were programmed. Twenty-eight words made up the non-programmed list. Every fourth word from the programmed and non-programmed lists was used for spelling tests. Students received fifteen to twenty minutes of daily teaching machine instruction for two months. Measures of progress included programmed words known, non-programmed words known, spelling programmed words, spelling non-programmed words, and the Gates Primary Reading Test.

The most important finding in this study, in the authors' view, was that the machine-taught students in the public schools' sample in every case more than doubled their programmed word recognition scores. Less than 5% of the conventionally taught students did as well. The same pattern held for the institutional sample. On most indicators of gain, the machine groups surpassed the conventional groups. Malpass et al. (1963) concluded that

"...automated instruction seems to offer a practical method for teaching reading to the retarded" (p. 71).

A study of the use of teaching machines to present reading and arithmetic programs (Blackman, 1964) was performed in a state institution for mentally retarded children in New Jersey. Reading programs covered word recognition, sentence recognition and comprehension, phonics and story comprehension. Arithmetic programs included rational counting, simple addition, subtraction, multiplication and division. The teaching machine employed in this study presented information on film and tape. The students responded by pressing one of four buttons. The correct answer advanced the filmstrip to the next frame. An incorrect answer resulted in a stationary frame until the correct answer was given. Correct and incorrect answers were identified by green and red lights.

Forty educable mentally retarded students were divided into two machine groups and two conventionally taught control groups, by age. Groups were matched for IQ and reading and arithmetic achievement levels. Machine groups spent two hours on the programs out of a ten hour school week. The study lasted an entire school year. Students were tested on the Wide Range Achievement Test, the Wechsler Intelligence Scale for Children, the Metropolitan Achievement Test, and instruments specific to the project

(C&G). Behavior ratings were also taken.

The results of this study were predominantly negative. Excepting a single arithmetic achievement test (C&G) on which the machine groups scored higher than the controls, there were no significant differences in achievement between any of the two groups. The machine groups did show a significant improvement in behavior compared to the conventionally taught. Blackman (1964) questioned the quality of the programs used in the study.

A study of the use of teaching machines to present arithmetic programs to educable mentally retarded children (Higgins and Rusch, 1967) was performed in the public schools of Albany, New York. The device developed for the project, known as the Audio-Visual Manipulative (AVM) Desk, presented visual and auditory information to students with a slide projector and a tape player. The students responded by manipulating objects or writing on the desk. To continue the program, students pressed a button on the desk.

Four classes of educable mentally retarded children comprised the sample. Two received machine instruction. The others were conventionally taught. Each student in the machine groups went through 21 arithmetic programs over a period of four months. Topics covered included cardinal numbers, more than/less than, and counting and enu-

meration. The students were tested with instruments specific to the project.

The machine groups scored significantly higher than the controls in this study. A second experiment revealed that a further increase could be obtained when students were exposed to the programs twice. Another indicated that the AVM Desk was inappropriate for trainable mentally retarded students. The authors concluded that the project had demonstrated the effectiveness of programmed instruction.

Most studies have shown that teaching machines were useful in the instruction of educable mentally retarded children. In the opinion of this author, the more sophisticated machines have been made obsolete by computer assisted instruction. The simpler ones, composed of paper, cardboard, and plastic, may still be cost-effective.

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Annotated Bibliography

Stolurow, L. (1961). Teaching by machine. (OE-34010 Cooperative Research Monograph No. 6). Washington DC: U.S. Government Printing Office.

Excellent survery of the field of teaching machines at its height. Provides review of the literature, description of individual devices, and analysis of programming; discusses several studies on exceptional children; anticipates future role of computers.

Blackman, L. (1964). The development and evaluation of a curriculum for educable mental retardates utilizing self-instructor devices or teaching machines. (Report No. NDEA-VIIA-368). Bordentown, NJ: Edward R. Johnstone Training and Research Center.

Detailed account of teaching machine study with negative results. Author suggests procedure was flawed. Contains excellent review of the literature; also provides glossary; over one hundred pages of theoretical background material.

Chapter 2: Current State of the Art

The primary educational application of computer technology is computer-assisted instruction (CAI). Winters, Hoots, and East (1978) defined CAI as "...an interactive learning environment in which the computer presents and responds to information given to it by the learner for the purpose of facilitating performance on the part of the learner" (p. 1). A CAI system--the hardware--consists of a systems unit, to perform operations, and peripheral devices, which input data from the user to the systems unit, and output processed data back to the user.

The major components of the systems unit are the central processing unit (CPU) and the main computer memory. The CPU is an integrated circuit chip capable of performing one million calculations per second. The main memory section comprises read only memory (ROM) and random access memory (RAM). ROM permanently stores information on basic computer functions. RAM temporarily stores information from individual programs, magnetically encoded on disk or tape. Peripheral devices include the keyboard, monitor, touch screen, printer, speech synthesizer, and disk drive.

There are three options for presenting educational software. Teachers can create their own programs, individualized to students' needs, by using a computer language. This requires a great deal of time. Professionally programmed software is convenient, but relatively

inflexible. A third alternative, authoring programs, combines some of the convenience of packaged software with the individualization of teacher-programmed lessons.

CAI software is classified by educational approach. Four kinds of software frequently used with mentally retarded students are:

1) Drill and practice

2) Tutorial

3) Simulation

4) Instructional game.

Drill and practice is the most commonly used software with mentally retarded students (Bull, Cochran, & Snell, 1988). Budoff, Thormann, and Gras (1984) described it thus:

> It is designed to help integrate and consolidate previously learned material through practice on the computer....It serves as a supplement to other forms of instruction. The common model for drill and practice software is the workbook. More sophisticated software can exceed the workbook by noting the items the child has failed, inserting them in the next series of items to be learned, and fading them as they are learned. (p. 81)

Tutorial software is less widely available than drill and practice (Budoff et al., 1984). It is described by

Budoff et al. as follows:

> A tutorial program places the computer in the role of teacher. Material is presented and the computer interacts with the child by questioning him on the material and responding to his responses. Depending on the nature of the response, the computer offers new information, repeats the question, or recycles the student through that section of the tutorial. The student moves through the program in sequenced steps by answering questions, and may be branched to remedial or review segments as well as continue to more advanced levels. (p. 82)

Behrmann (1984) observed that, "...it is tutorials with built-in authoring systems that allow teachers to meet many of the individual needs of mildly or moderately disabled students" (p. 90).

Nave and Browning (1986) provided the following description of simulation:

> Educational simulations present important aspects of real-world situations to the students and require decision making at key points in the process. The computer evaluates each decision, informs the student of the consequences of that decision, and then presents the resulting options for the new decision point. Thus, the student becomes engaged in active problem

solving to accomplish some predefined goal.

> Simulation programs are applicable across a large number of content areas....Specific examples with applicability to developmentally disabled persons include shopping, budgeting money, and job interviewing. (p. 101)

Bright and Harvey (1984) defined a computer instructional game as "...a game for which a set of instructional objectives has been determined, with the computer playing the role of either a mediator for human opponents, or an alternate opponent for a human player" (p. 74). Computer instructional games may provide drill and practice, tutorial instruction, simulation, or a combination (Wiebe, 1987). Teachers should take care that students do not become preoccupied with the entertainment of such games at the expense of learning (Bright & Harvey, 1984).

The advantages of CAI for special education were described by Budoff et al. (1984):

1) Individualization and self-pacing: With well-programmed CAI, special education students work at their own pace with material that meets their specific needs. In addition, rate of presentation and response may be regulated for each student.
2) Immediate feedback: Students receive immediate feedback about their performance.

3) Consistent correction procedures: Special education students are often confused by corrections that are too wordy. CAI can provide specific, consistent correction for errors.

4) Repetition without pressure: Since the computer is emotionless and infinitely patient, repetitive tasks may not be aversive or embarrassing for the student.

5) Immediate reinforcement for correct responses: The software provides immediate positive reinforcement for correct answers, which motivates students.

6) Well-sequenced instruction: A task may be analyzed, broken down into manageable steps, and then programmed. Special education teachers often do not have the training or time to construct the consistent, well-sequenced instruction that most special education students need, and that good software can provide.

7) High frequency of student response: If the interactive features of the computer are put to full use, students get more practice solving problems than they do working in large groups or with work sheets.

8) Repeated demonstration of mastery of academic subject matter: A sense of mastery...is very important to students who have experienced and continue to experience failure in instruction. The com-

puter allows them to review their earlier attainments and recall them.

9) Peer response: Computer use by students in the special education setting may be viewed positively by other students who do not have computers in their classrooms.

10) Motivation: This can be described at two levels. Many special education students are excited by working on a computer, even doing class work. For others, it is an excellent motivator to allow time for computer games as a reward for work completed. Earning computer time may result in more focused and concentrated work by easily-frustrated students who produce slowly or not at all in their usual assignments.

11) Improvement of motor skills and visual motor coordination: Playing computer games with a paddle or joystick improves a student's gross and fine motor skills and visual-motor coordination.

12) Minimize disabilities: The computer enables the poor or inefficient learner to minimize or circumvent significant barriers to learning. (pp. 77-79)

Many studies have shown that CAI is effective with mentally retarded students (for literature reviews see

Conners, Caruso, and Detterman, 1986; Lieber and Semmel, 1985). Thirteen of them are summarized here.

An early study of the use of CAI to teach mentally retarded students to make change from one dollar (Knutson & Prochnow, 1970) was performed in Texas. Instruction was delivered by a mainframe computer, interfaced with remote terminals and slide projectors, insofar as the project antedated the development of microcomputers. Mainframes provided greater flexibility in programming, but access was costly and connections unreliable. The authors experienced considerable difficulties in their pioneering effort to write a suitable tutorial program, but ultimately were successful.

Thirty-one students from three special education schools were selected for the course. The group, as a whole, made statistically significant gains from pre-test to retention in the change-making skills covered in the program. However, several students benefitted only slightly. Knutson and Prochnow (1970) felt that in these instances the impersonality of computer instruction was probably not desirable.

The authors concluded that it would be worthwhile to develop additional survival skills programs for the retarded.

A study of the use of CAI to teach vocabulary words

to mentally retarded students (Nelon, 1972) was performed in Syracuse, New York. Instruction was delivered by a mainframe computer linked to remote typewriter terminals. Monitors were not employed. Students were presented with words or phrases on the terminals, and asked to type them. Remediation consisted of filling in missing letters or words. Finally, students were asked to type words or phrases from memory. Nelon drew upon the literature of teaching machine studies with the mentally retarded as background for her study.

The subjects were divided between two experimental groups of 12 educable mentally retarded students and 12 normal students, and corresponding control groups. Students' mental ages were on the first grade level. Both experimental groups showed statistically significant differences in post-test scores compared to the controls. The author concluded that the program was effective.

A study of the use of CAI to teach arithmetic skills (Richardson, 1974) was performed in suburban Maryland. Terminals were linked to an IBM mainframe in a local high school. Programs consisted of drill and practice. Ten secondary students from a special school for the retarded served as subjects. Once a week they traveled to the terminals and received 40-50 minutes of computer time. In-

struction lasted four months. Students' scores on the arithmetic section of the Wide Range Achievement Test increased significantly from pre-test to post-test.

A study of the use of CAI to teach skills prerequisite to money handling (Holz, 1979) was performed in Calgary, Alberta. A monitor interfaced with a slide projector and a teletypewriter was used in the project. The peripherals were connected to a minicomputer. Four tutorial programs were employed, covering numeral recognition, counting to 99, simple addition, and coin recognition.

The experimental and control groups consisted of thirty-two students from a school for trainable mentally handicapped students. Students ranged in age from 7 to 20, with a mean of 15. Training lasted for 1½ months. Students were scheduled 20 minutes of computer time each day.

Effectiveness of instruction was measured by a test the experimenter developed. The training group showed a statistically significant improvement in money skills compared to the control. The author noted that the programs were well suited to the use of microcomputers.

A study of the use of CAI to teach number conservation skills to mentally retarded students (Lally, 1980) was performed in Canberra, Australia. Instruction was delivered by mainframe computer linked to monitors and button keyboards. Digitized speech was employed to give directions.

Twenty mildly retarded students from a special education school were assigned to experimental and control groups. The program presented the trainees with rows of colored squares, and asked them whether or not the rows were equal. Each session lasted twenty minutes. Training took place four times a week, for four weeks. The control group received their usual classroom instruction.

Five out of ten students from the experimental group demonstrated conservation of number after training. Only one student from the control group did so. The author concluded that the program was partially successful.

A study of the use of CAI to teach handwriting to mentally retarded students (Lally, 1982) was performed in Canberra, Australia. Subjects were trained to write lower case manuscript letters and numerals 0-9. A light pen and display screen linked to a mainframe computer was employed in the project. A cursor box followed the pen tip around the screen. Writing was cued by a blinking spot just outside the box.

Subjects were nine mentally retarded boys, ranging in age from 9 to 16, from a special education school. They received twenty minutes of training, four times a week. for four weeks. Three cursor box sizes were used in the study--large, small, and large decreasing to small.

Reducing the cursor box made the task more difficult.

Students working with the gradually reduced cursor box greatly improved in writing the programmed alphanumeric forms. Using only a large or small cursor box was not as effective. The author stated that the advent of microcomputers should make computer-assisted handwriting instruction more economical.

A study of the use of CAI to teach sight word recognition to mentally retarded students (Lally, 1981) was performed in Canberra, Australia. Students worked on a keyboard containing 16 buttons covered by an overlay of sight words. Twelve overlays were used for 105 words--there was a large amount of repetition. The experimenter was required to change the overlays. Lally noted that the introduction of touch screen monitors had made it possible to deliver the program without teacher involvment.

Subjects were 16 children, between 9 and 16 years of age, from a special school for mildly and moderately retarded students. Trainees received instructions from a computer equipped with digitized speech. Students were told to press a button corresponding to a word spoken aloud. When 14 out 16 words were correctly identified, students advanced to the succeeding overlay.

Students were divided into experimental and control groups. Both groups continued their usual classroom lessons on the same words. The training group had twenty minute CAI sessions, four times a week, for four weeks. The experimental group outpaced the control group in programmed words recognized. Results were statistically significant. Lally (1981) viewed the study as support for CAI supplementing conventional classroom instruction.

A study of the use of CAI to teach special education students mathematics (Hummel & Hummel, 1982) was performed in Michigan. Microcomputers linked to keyboards and monitors were used. The authors set out to compare traditional classroom instruction, packaged software, and specially authored programs. Ninety students, identified as learning disabled, mentally retarded, or emotionally disturbed, from twenty-one special education classes, on elementary, middle, and high school levels, served as subjects.

Results were mixed. On the middle school level, the authored programs demonstrated superiority to commercial software, which, in turn, was found preferable to conventional instruction alone. However, these findings were not replicated for the elementary and high school grades. The authors cited difficulties in implementing the research design to account for this.

A study of the ASSIST authoring system in special education (Chiang, 1978) was performed in northern California. Remoted teletypewriter terminals linked to a minicomputer were used. Lesson models were primarily drill and practice.

Approximately two hundred students from different schools, identified as learning disabled, educable mentally retarded, emotionally disturbed, and language handicapped, took part in the project. They were matched to control groups for evaluation. CAI was used to supplement conventional instruction for an entire school year. Scheduling computer time was at the teachers' discretion. Students averaged thirty-three minutes per week system usage.

The KeyMath Diagnostic Arithmetic Test and the Reading Recognition and Reading Comprehension subtests of the Peabody Individual Achievement Test were used for assessment. The treatment groups scored a moderate overall gain compared to the controls. The author concluded that the ASSIST authoring system had proven useful and effective in special education classrooms. She recommended that the system be adapted for use on microcomputers to make it more accessible. Chiang (1978) also suggested that the system could be further improved by presenting lessons on monitors rather than teletypewriters.

A study of the use of CAI to teach children how to to tell time (Friedman & Hofmeister, 1984) was performed in a resource room in Logan, Utah. The system consisted of a microcomputer, videodisc player, and a touch screen monitor. The instructional program taught children to tell time to 5 minute intervals. The lesson sequence included number placement on a clock face, discriminating the hour hand from the minute hand, identifying the values for the minute and hour hands separately, identifying the values for the minute and hour hands together, and reading digital format. The criterion for mastery on each segment test was 80% accuracy.

The program was tested on four first and second graders. None of them were able to tell time. Three were classified learning disabled, and one as educable mentally retarded. The students worked for fifteen minutes each day over a six week period. All of them met or exceeded the 80% mastery level for every instructional objective. The program has succeeded without teacher assistance.

The authors eschewed comparisons between teacher and computer. They envisioned CAI as a supplement to teacher-student interaction, not a replacement.

A CAI program to teach social skills to handicapped children (Thorkildsen, 1985) was developed at Utah State

University. A microcomputer, videodisc player, and touch screen monitor were used to deliver instruction. The program provided direct instruction using realistic examples of appropriate and inappropriate social interaction. Students were presented with the consequences of their responses to interpersonal problems. They were taught how to use phrasing, intonation, and body language in social situations (Hofmeister & Thorkildsen, 1987).

A study of the social skills program was conducted in a northern Utah school district in 1984. Six elementary school resource rooms, each containing five mildly handicapped students, were randomly assigned to experimental and control groups. Students were classified as neglected, accepted, or rejected.

After four months, the experimental groups scored significantly higher on measures of social skills covered in the program, and peer acceptance. However there was not a significant difference between the two group's self-esteem ratings. The author stressed the importance of peer acceptance.

A study of the use of CAI to teach living skills to special education students (Browning, White, Nave, & Barkin, 1986) was performed in Oregon high schools. A videotape player, which required more teacher involvement than

a videodisc unit, computer, and a monitor were employed in the project. Students were presented with simulated experiences, in which they were asked to make decisions about asking people for help. Teachers led students in discussion of their reponses and the ensuing consequences as depicted in the program.

One hundred five subjects, categorized as mildly or moderately handicapped, took part in the study. A series of eight lessons were taught over a two week period. Five instruments were used to evaluate the program. Students in both categories made statistically significant gains in their knowledge of the programmed material and its application. Both teachers and students expressed favorable opinions about the lessons. The authors were optimistic about the future of CAI with handicapped children.

Harper and Ewing (1986) compared the effectiveness of microcomputer and workbook instruction in reading comprehension. The program used was Comprehension Power (1981) by Milliken Publishing Company. The workbooks were the Readability Comprehension Series (1980), published by Lippincott.

Nine learning disabled and mentally retarded students assigned to a junior high school resource room served as

subjects. The study was divided into baseline, alternating treatments, and follow-up. During the second phase, students received alternating microcomputer and workbook instruction daily, four times a week, for four weeks. The effectiveness of each twenty minute session was measured by percentage of correct answers on a reading comprehension test. Eight of the students performed better with microcomputer instruction. The ninth student expressed fear of computers. All students showed little difference between microcomputer and workbook instruction in attention to task behaviors.

Conners and Detterman (1987) have related performance on a computer-assisted word learning task to basic cognitive abilities. The degree of learning was correlated with probed recall, stimulus discrimination, and simple learning skills. The authors suggested that computer-assisted instruction be individualized to reflect differences in these areas.

Computer-assisted learning (CAL) differs from CAI in that it "...allows the student to be in charge of the computer, directing the interaction" (Turkel & Podell, 1984, p. 259). CAL includes programming languages for children, such as LOGO, and talking word processors. LOGO has applications in graphics, language arts, and mathemat-

ics. Talking word processors have shown great promise in improving Down's syndrome teen-agers' written and oral language (Meyers, 1986).

Lieber and Semmel (1985) have commented that the instructional advantages of microcomputers had previously been attributed to teaching machines in the 1960's. This is not surprising--teaching machines were replaced by better teaching machines, i.e. computers. However it is likely that computers will remain in education for some time to come. Ron Thorkildsen put it this way: "It may be reminiscent of various types of teaching machines that have come along, but...the flexibility this technology offers is unlimited" (Thomas,1981, p. 268).

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Good general survey; well-written and informative. May be difficult to use in that it does not address disabilities individually, and lacks an index. Chapters on languages and packaged software, authoring instruction, and computer administrative uses.

Goldenberg, E., Russell, S., Carter, C., Stokes, S., Sylvester, M., & Kelman, P. (1984). Computers, education, and special needs. Reading, PA: Addison-Wesley Publishing Company

Focused on CAL applications. Graceful and non-technical, but readers wishing to know more about CAI will have to look elsewhere.

Hagen, D. (1984). Microcomputer resource book for special education. Reston, VA: Reston Publishing Company.

Book is divided equally between narrative and appendixed reference material. Both sections are useful. Eighty-seven pages on commercial software; special section on LOGO.

Conner, F., Caruso, D., & Detterman, D. (1986). Computer assisted instruction for the mentally retarded. In N. Ellis (Ed.). International review of research in mental retardation. (Vol. 14). New York: Academic Press.

Most recent and comprehensive review of CAI. Cites 15 effectiveness studies with retarded subjects. Calls for more individualized CAI.

Lindsey, J. (Ed.). (1987). Computers and exceptional individuals. Columbus, OH: Merrill Publishing Company.

Best overall survey. Covers all disabilities. Chapters written by leading experts. Sections on LOGO and videodisc technology. Excellent glossary; seven appendices.

Behrmann, M. (1988). Integrating Computers into the Curriculum. Boston: College Hill Press.

Focused on applications. Chapters written by leading experts. Includes sections on robotics, telecommunications, and word processing. Information on computer networks such as DIALOG and SpecialNet contained in Appendix.

Chapter 3: New Directions

New applications of computer technology are expected in the areas of simulation, artificial intelligence and robotics. In a study conducted by Moore, Yin, and Lahm (1986) their potential uses were rated by special education and technology experts. Simulation and artificial intelligence were adjudged the most promising in the foreseeable future. Developing simulation presents the fewest technical barriers; robotics, the most.

Simulation was described in Chapter 2 of this study (pp. 14-15). Pollak (quoted in Hagen, 1984) stated, "The video disk alone contains all previous educational technologies rolled into one--from the chalk and slate to the slide/tape show. Combine that with the power of the microcomputer and it's dynamite" (p. 94). In an interview with the author Mittler (1989) commented:

> I'm a strong believer that the long-term future of video, particularly video disk technology in the education of the handicapped will prove beneficial.... I think handicapped learners as well as the average school learner, is now currently become a video intensive learner through television and what-not. We can't change that. I don't think education has created that. I don't think education can run from

that. So I think we're starting with video as a very traditional form of providing information. Let me be extremely clear in terms of the handicapped learner. I think the greatest disability that handicapped learners face is their inability to take what they learned in the classroom situation and apply it to an out-of-classroom situation. Short of spending considerable instructional time out of the classroom in the real world, I think video provides one of the best ways of simulating the real world, and I think therefore video will prove to be of tremendous benefit to the handicapped, probably even greater benefit than it will to the nonhandicapped. (pp. 5-7)

Implementation of computer simulation may be delayed by film production costs (Behrmann, Stevens, & Levy, 1984).

Lindsey (1987) defined artificial intelligence as "...a new emphasis in computer science that uses computers to solve problems that require knowledge, intuition, or imagination" (p. 294). Potential uses of artificial intelligence in special education include expert systems and natural language analysis.

Expert systems apply the specialized knowledge of human experts to problem-solving tasks. Development of expert systems

may be expensive and time-consuming (Moore, Yin, & Lahm, 1986). Mittler (1989) said that expert systems in special education will be used primarily for diagnosis and planning. Expert systems have been programmed to diagnose learning disabilities and assist teachers in devising behavior modification strategies (Hofmeister & Lubke, 1986). Mittler described the misuse of:

> ... an expert system that's been created to diagnose learning disabled youngsters and to decide whether in fact they meet the definition of learning disabilities. That expert system was not designed, nor was it claimed by the designers, to be better than a human in making that diagnosis. Yet there is a state in this Union that was using that expert system to take kids out of special education, even though the professionals had put the kids in special education. When you have that in place, then you have a potential misuse of something that exists called an expert system. That's frightening, quite frankly, when you can manipulate kids with something that really was not intended to have that kind of purpose. (pp. 16-17)

Bull, Cochran, and Snell (1988) suggested that expert

systems may also be used as an adviser to mentally retarded persons in performing activities of daily living.

According to Behrmann, Stevens, and Levy (1984), "Natural language analysis allows the computer to interpret either textual or spoken language....The computer is made to conform to the rules of the user's language, rather than the user conforming to the computer's language" (p. 258). Natural language analysis may make computers more accessible to handicapped students, who find programming difficult.

Mittler (1988) described personal service robots as follows:

> Most stand between 18 inches and a few feet in height and are typically powered by an on-board system of rechargeable batteries. They typically move about on wheels, although the number and positioning of the wheels vary. Personal robots can be programmed to perform several tasks simultaneously or in sequence. They usually have an on-board microprocessor and keyboard, although some may be programmed by an external computer. Senses that are available on most personal robots include the ability to respond to sounds, light, motion, objects, touch, and heat. Some have

an arm that extends and has a gripper at its end. The arms are currently limited in their strength and can lift no more than several ounces. Many have a built-in voice synthesizer that enables them to 'speak' to their owners. (p. 91)

He envisioned the following educational applications:

1) Reminding the student of scheduled activities and responsibilities.
2) Demonstrating correct social behaviors.
3) Reminding the student of a correct response.
4) Modeling language for language-impaired students.
5) Performing motor tasks for physically limited students.
6) Monitoring the environment for sounds, noises, or words for the hearing impaired.
7) Monitoring stereotypical behavior and reminding the student to stop.
8) Planning a sequence of steps to accomplish a goal. (pp. 92-93)

The use of personal robots in education has been declining recently. Mittler (1989) observed that:

> The field has dried up. What's happening in robotics since that was written [Mittler, 1988] was that the early developers of robots, as businesses, have

not been successful. They primarily weren't successful for two reasons--one being that the technology was not as well-developed as they would have liked, programming a robot was difficult, and programming a robot would be too difficult for the average person to start using robots. At the same time there was no press on the need side. Not too many people were interested in trying it. But there was primarily a programming issue, really, which became very difficult. It became easier to use a computer with a mouse, with pictures, with icons to control technology than to try to use machine code or some other way of programming a robot. By the way, as Moore, Yin, and Lahm [1986] pointed out, the field of robots is a tough field, so that kind of stopped. There is some development that is continuing in the rehabilitation area and that is still under development, but the actual availability of robots to the schools sort of dried up. The ones that were bought by schools are probably gathering dust, becoming aging robots in the corners of the classrooms. So that has not come. (pp. 13-14)

Conners, Caruso, and Detterman (1986) identified two main areas in which research on CAI for mentally retarded students is needed: "...methods for individualizing CAI and methods which address the group characteristics of the mentally retarded" (p. 126).

A study by Conners and Detterman (1987) on individualizing CAI programs for word recognition was described in Chapter 2 of this study (p. 28). Hasselbring, Goin, and Bransford (1988) found that a tutorial program in basic math facts, individualized to each student's level of automaticity and supplemented with computerized drill and practice, was highly effective in promoting recall fluency.

One hundred sixty mildly handicapped and non-handicapped students, ages 7 to 14, served as subjects. An experimental group of mildly handicapped students received 10 minutes of tutorial and drill and practice CAI daily. Two control groups of handicapped and nonhandicapped students received their usual arithmetic instruction in class. After forty-nine days the average number of facts recalled from memory by the experimental group had increased 73%. The handicapped control group showed no change, while the nonhandicapped control increased only 20%. The authors

concluded that "...with sufficient training, learning handicapped students should be able to develop automaticity at a level commensurate with their non-handicapped peers" (p. 7).

Grimes (1981) identified group characteristics of mentally retarded students that should be addressed in CAI programming. Carter (1984) listed them as follows:

1) Selective or poor attention to relevant learning stimuli.
2) Difficulty with visual discrimination or reading.
3) Inappropriate response times.
4) Short-term memory deficits.
5) Inability to transfer and generalize learning to new situations.
6) Inability to recognize mistakes. (p. 4)

The author asked Mittler (1989) whether the enthusiasm for computers might not subside, and computers fade from the educational scene. Mittler responded:

> I think it's possible....It is certainly my hope that it doesn't happen....There are lots of scenarios that would make that possible, including misuse by teachers, including budget cuts by districts, including changes in attitudes towards handicapped kids that

> say they should not be getting resources such as that. There are lots of constraints that have nothing to do with learning or technology that may impact that. However, I think it's safe to say that this concept of technology has been integrated into the lives of the rest of the world outside of education, that the business world is not giving up on technology, that the jobs in the twenty-first century will be using technology. And as long as we maintain a demand to tie education to careers, and we should, and we do, and we will, then the computer will become part of it. (pp. 18-19)

Ogle ("Families and Telematics," 1982) argued that education should be shifted away from the teacher in school towards computerized instruction at home. However, it is important that the human element not be lost in the learning process. Gerstein ("Computers to Revolutionize," 1983) is "...concerned about the possibility of the home computer and home education alienating students and families from the community and society" (p. 3).

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Survey of experts on outlook for new technologies. Computer simulation is the most promising. Robotics is the least developed. This article is a summary of a report.